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THE TAXONOMIC OUTLOOK IN ZOOLOGY[1]

By W. T. CALMAN, D.Sc., F.R.S.

THE selection of a systematic zoologist for the honor of addressing you from this chair implies a belief that systematic zoology may have something to say that will not be without interest to those whose studies lie in other fields. I am not sure how far this belief is generally shared. The anatomist, the physiologist, the field naturalist, the student of one or other of the innumerable specializations of biological science, has always been inclined to regard with distaste, if not with contempt, the work of those whose business it is to denominate, classify and catalogue the infinite variety of living things. The systematist is generally supposed to be a narrow specialist, concerned with the trivial and superficial distinctions between the members of some narrow group of organisms which he studies in the spirit of a stamp collector; happy when he can describe a new species, triumphant if he can find an excuse for giving a fresh name to an old one.

[1] Address of the president of Section D—Zoology, British Association for the Advancement of Science, Bristol, September, 1930.

It would be idle to deny the truth that there is in these criticisms, just as it would be easy, although unprofitable, to point out that the substance of them might be directed against the practice of most other branches of research. The specialist, of whatever kind, has a tendency to mistake the means for the end, to become fascinated by technique and to suffer from a myopia that blurs his vision of other fields than his own.

I think, however, that there are some signs of an increasing appreciation of the usefulness and even of the scientific value of taxonomy among the younger generation of zoologists. More particularly, those who are concerned with the applications of zoology to practical affairs are, for the most part, although not invariably, aware of the need for exact identification of the animals they deal with. They do not always realize the difficulties that may stand in the way of this identification. It is a common experience with us at the Natural History Museum to have some mangled fragments of an animal brought in by a

practical man who expects to be supplied with the name of it while he waits. I am afraid that he often goes away with a low opinion of our competence.

It may not be without interest, therefore, if I attempt, in the first place, to give some idea of how matters stand with this part of the systematists' task, the identification and description of the species of living animals.

When Linnaeus published in 1758 the first volume of the tenth edition of his "Systema Naturæ" he named and described about 4,370 species of animals. If we ask how many are known to-day the diversity of answers we get is some indication of the confusion that exists. Some years ago, at the request of the late Sir Arthur Shipley, I endeavored to get from my colleagues at the museum estimates of the numbers of species in the various groups with which they were specially conversant. Some of the answers obtained were very interesting. With regard to mammals I was told "anything from 3,000 to 20,000 according to the view you take as to what constitutes a species." For the most part, however, the authorities consulted were unwilling to suggest even an approximate figure for a very different reason. They told me that great sections of the groups with which they were concerned were so imperfectly surveyed that it was quite impossible even to guess how many of the supposed species that had been described would survive reconsideration.

It may be worth while to consider for a little the second of the two obstacles thus indicated as standing in the way of obtaining a census of the known species of animals. In the days of Linnaeus it is likely that a very experienced zoologist might have been able to recognize at sight any one of the four thousand species of animals that were then known, and when the expansion of knowledge had made such a feat no longer possible, the specialist who confined his studies to one section of the animal kingdom could still aspire to a like familiarity with the species of his chosen group. With this kind of knowledge it is literally true that, as has been said, a systematist recognizes a new species by instinct and then proceeds to search for the characters that distinguish it. Some of the great zoologists who were still working in the British Museum when I entered it more than a quarter of a century ago, men like Albert Günther, Bowdler Sharpe, C. O. Waterhouse and Edgar Smith, had actually an amazing personal familiarity with vast sections of the animal kingdom. They had studied and digested all that had been written on their subject, and if they did not carry the whole of this knowledge in their memory, they could without searching put their hand at once on the volume that would help them. They had no need of "Keys" to help them to run down their species, indeed they rather distrusted such aids for they knew how easily they betray the heedless. Specialists of this type there must always be and we may be thankful for it. Nothing can altogether replace that instinctive perception of affinity that comes from lifelong study. It has often happened that men such as those I have named were able, when confronted with new and aberrant types of animals, to allot them at once to a place in classification which subsequent research served only to confirm. As time goes on, however, the extent of ground that can be covered in this fashion by the most industrious worker is rapidly diminishing. The torrent of publications catalogued in the *Zoological Record* increases year by year, and the specialist, if he is not to be overwhelmed by it, must not allow his curiosity to stray beyond the limits of a narrow corner of the field.

By far the greater part of this literature is written by specialists for specialists, and much of it is unintelligible to any one else. From the time of Linnaeus, however, there have not been wanting publications that have a different aim. We have monographs, synopses, revisions, of all sorts and sizes, attempting to render possible the identification of species without demanding a lifetime of study for each special group. The ideal for such monographs would be, I assume, that they should be intelligible to, and render possible the determination of species by, any properly trained zoologist, even without previous experience in dealing with the particular groups of which they treat.

The zoological department of the British Museum may fairly claim to have done more towards this reediting of the "Systema Naturæ" than any other institution in the world. The long series of monographs, of which the true character is somewhat concealed under the official title of "catalogues," is a monument to the learning and industry of the great zoologists who planned and executed them. Though they remain indispensable to all serious students of the different groups, however, they are now for the most part long out of date, and vast as is their scope, they cover only a fraction of the animal kingdom.

In 1896 the German Zoological Society began the publication of "Das Tierreich," afterwards continued by the Prussian Academy, which was planned to give nothing less than a revision of all the species of living animals. Here again, however, after thirty-four years, only a small part of the ground has been covered and already the progress of research has rendered many of the earlier parts obsolete. Colonel Stephenson tells me that Michaelsen's revision of the Oligochaeta, published in this series in 1900, deals with exactly half the number of species enumerated by the same authority in 1928.

Apart from these attempts at comprehensive revision we have, of course, numerous surveys of local

faunas on a larger or smaller scale, besides monographs of restricted groups, but hardly ever do these fit together without leaving gaps, geographical or systematic.

Take, as an example, the brachyurous Crustacea or true crabs. No revision of the Brachyura as a whole has been attempted since Henri Milne-Edwards' "Histoire Naturelle des Crustacés" published nearly a century ago. The student who wishes to identify a collection of crabs has to begin with local faunas, such as Alcock's invaluable "Materials for a Carcinological Fauna of India" and Miss Rathbun's monographs of the American species; but for regions that have not been thus studied there is no way but to search out and compare the descriptions of species in innumerable obscure publications by writers who had often an imperfect knowledge of what had been done elsewhere. The genus *Pilumnus* is one that is abundantly represented in all the warmer seas of the globe. No revision of its numerous species has been attempted in recent times. I do not even know how the genus is to be defined from neighboring genera; and yet hardly any report on a collection of tropical crabs does not profess to describe at least one new species of the genus.

Another example from a very different group of animals is given by the aberrant lamellibranch Mollusca forming the family Teredinidae, commonly known as "shipworms." During the past ten years a great deal of attention has been given to these animals in the effort to discover means of combating or avoiding their attacks on the timber of harbor works and the like. Nevertheless, the taxonomy of the group remains in a state of the utmost confusion. There is no agreement as to the limits even of the genera, and the inconstancy of the characters that have been used for the definition of species is plain to any one who studies a large collection. Only in one species, the long-known and often-studied *Teredo navalis* of Linnaeus, have we any detailed information as to variability and the changes that take place during growth. In these circumstances the publication of new specific names, except after prolonged study of ample material, can not be regarded as a serious contribution to knowledge. Dr. Bartsch, of Washington, in his "Monograph of the American Shipworms" (1922) simplified his task by the assumption that any species found on the coasts of the American continent must, of necessity, be different from any found elsewhere, and he was thus able to write "n.sp." after twenty-two out of the twenty-nine specific names. It was soon shown, however, by other American zoologists, that this assumption was without foundation, and that the most destructive species on both the Atlantic and Pacific coasts of North America was the European *Teredo navalis*.

A thorough revision of the taxonomy of the shipworms would be a task of much difficulty but it would be of great scientific interest and it might even be of great practical importance. Those who are carrying out experiments on the protection of timber, in this country at least, seldom trouble to inquire what species they are dealing with or even whether they are always dealing with the same one. Professor Barger, for instance, who speaks of *Teredo* as a "species" does not seem to think that it matters. Perhaps it does not, but it is just possible that it does. We do know that different species differ greatly in susceptibility to changes in the salinity of the water, and it seems worth while to ask whether they all react in exactly the same way to the poisons that the chemists try to administer to them. The fact that our knowledge of their specific differences is still very incomplete is no reason why the chemists should not avail themselves of such knowledge as we have.

One cause that has encumbered systematic literature with uncounted pages of useless writing is the prevalent delusion that it is possible to give what is called a "complete description" of a species. This phrase is apparently intended to denote an enumeration of the visible features of the organism so exhaustive as to include not only the characters differentiating it from the other species already known but also those that will serve to distinguish it from species yet to be discovered. Now a moment's reflection will show that a lifetime would not suffice for the complete description of any animal whatsoever, and on the other hand, a very little experience will convince one that it is impossible to predict the kind of characters that will distinguish the next new species. Some years ago I found that all the specimens of the genus *Squilla* in the museum collection from West Africa differed in half a dozen constant, and, once they were pointed out, conspicuous characters from their nearest congeners. It happened that shortly before a German zoologist had given what was intended to be a complete description of a *Squilla* from the same region. His account extended to two large quarto pages, and yet it succeeded in avoiding mention of every one of the features that proved to be distinctive of the species.

If every one who describes a new species were to restrict himself to a bare enumeration of the characters in which it differs from all the known species of its genus, systematic papers might be vastly diminished in bulk, although one suspects that the labor necessary to write them might be correspondingly increased. It may be a counsel of perfection to suggest that no one should introduce a new specific name without undertaking at least a partial revision of the genus including it, but there are very many instances where the multiplication of species might with advan-

tage be postponed until we learn something about those that are supposed to be known.

The number of described species of animals has been estimated at something in the neighborhood of three quarters of a million. It is not at all improbable that between a quarter and a third of that number would be suppressed as synonyms or put aside as *species inquirendae* by careful monographers and that in many groups the proportion would be far higher.

The prospect is not one that can be contemplated with any satisfaction. The successively expanding volumes of the *Zoological Record* give us a picture of systematic zoology being smothered under the products of its own activity. The confusion will grow steadily worse unless systematists come to realize that the mere description of new species is a far less important thing than the putting in order of those that are supposed to be already known, and until, on the other hand, zoologists in general cease to regard taxonomy as a kind of menial drudgery to be done for them by museum curators.

I have alluded to another obstacle to obtaining an enumeration of the animal kingdom in the divergences of opinion as to what constitutes a species. I am not sure that these divergences are not sometimes overestimated. I think that it will be found that in most orders of animals there exists a considerable body of species regarding whose limits there is no serious difference of opinion among competent systematists; but alongside of these we find in almost every order, in most families and even in many genera a difficult residue in which the delimitation of specific groups sometimes seems to be little more than a matter of personal taste. My colleague Mr. Robson has recently brought together a great deal of information on this subject in his book "The Species Problem" to which I would refer any one who needs to be convinced how complex the problem really is. For our present purpose it is enough to take the empirical fact that the majority of animals can, with more or less trouble, be sorted into assemblages or kinds that we call species. We have seen how imperfect and confused is the present state of knowledge even as regards the mere description and identification of these kinds.

The business of the systematist, however, does not end with identification. Even identification requires some kind of classification, if it is only the classification of the dictionary. Since the time of Linnaeus, or rather since the time of John Ray, zoological systematists have believed in the existence of a natural system of classification which it was their business to discover; since Darwin it has seemed plain that this natural system must be, in some way, based upon phylogeny. It has now realized that the relation between the two is not always so simple and straightforward as it once appeared to be. Dr. Bather, in his presidential address to the Geological Society in 1927, discussed the historical and philosophical bases of biological classification. He concluded that "the whole of our system, from the great phyla to the very unit cells, is riddled through and through with polyphyly and convergence" and that "important though phylogeny is as a subject of study, it is not necessarily the most suitable basis of classification." I am not sure that I quite understand what is implied by the second of these statements, but I do not suppose that even Dr. Bather would be prepared to suggest a system of classification entirely divorced from phylogenetic considerations.

Forty years ago the reconstruction of the evolutionary history of the major divisions of the animal kingdom was almost universally regarded as the chief end of zoological research. To-day, except among paleontologists, one might almost say that the phylogenetic period in the history of zoology has come to an end. When one recalls the extravagances of its later developments, the derivation of vertebrates from arachnids and of echinoderms from cirripedes, one can not be surprised that zoologists of the modern school take little interest in it. If we accept this attitude, it follows that problems of affinity and relationship are not worth worrying about. We are told, in so many words, that our business as systematists is identification, not classification; that what we have to do is merely to devise some kind of key or card-index that will enable animals to be quickly and easily sorted into species. As far as the really scientific branches of zoology are concerned an artificial system of classification is as good as, and may even be better than, any other. An illustration of this attitude of mind is seen in a paper recently issued from Cambridge in which *Lithodes* is replaced, without explanation or discussion, among the Brachyura—which, on the card-index system, is doubtless its appropriate place.

It is quite true that the categories of the physiologist, the ecologist, the geneticist, and so on, often cut across the dividing lines of the most natural classification we can devise, but both the divergences and the coincidences are worthy of closer consideration than they sometimes receive. If there is any truth in the theory of evolution it is obvious that functions and habits have an evolutionary history behind them, but it is no less obvious that this history has not been independent of the history of the organisms that display them. The details of this history we shall never fully know and even its broad outlines may perhaps always remain misty. A natural system of classification expressing even these broad outlines may prove to be an unattainable ideal, but each step towards it

holds out the promise of usefulness in other and possibly remote fields of research.

A great deal of current work and still more of current speculation in zoology seems to me to suffer from this neglect of the taxonomic outlook. In the zoology of the later nineteenth century the comparative method was still the chief tool of morphology. The relative importance of structural characters was measured by the extent of their persistence through larger or smaller divisions of the animal kingdom. This point of view tends to be lost sight of with the increasing emphasis on the experimental method. The systematic zoologist, in listening to the exponents of the modern lines of research, is apt to be impressed by the little account that is taken of the vast variety of animal life. To say this is not to underrate in any way the advances that have been made in these lines within the present century or the revolutionary changes they have made in our views on many fundamental questions. Physiology, for example, is to-day a vastly different science from what it was thirty years ago, partly because the physiological laboratory has a more varied fauna than it had then. Nevertheless, the zoologist, conscious of the unending diversity of structure and of habits among animals, sees the physiologist's results against a background of which the physiologist himself seems to be sometimes forgetful.

One hesitates to suppose that the students of heredity are really so forgetful of this background as they sometimes seem to be. No doubt intense specialization is needed for intense research; but the poet of the breakfast table, laughing gently at the narrow specialism of the Scarabee, can hardly have foreseen the day when a university in his own country would have upon its teaching staff an officer named in the university calendar as a "Drosophilist."

It is possible, however, that the prevailing lack of interest in questions of phylogeny may have a deeper significance. Those departments of biology that are being most actively studied at the present day are preoccupied with the interplay of forces acting here and now. They ignore the impressions that time may have left on the material of their study. It is as though a crystallographer, studying a pseudomorph, should endeavor to explain its form in terms of its chemical composition and the forces governing the arrangement of its molecules, without taking account of its past history.

From ignoring anything, it is but a short step to denying its existence, and here, it seems, we have already arrived. Some of you may possibly have listened to a lecture delivered in London in the early part of last year by that very distinguished experimental biologist Dr. Hans Przibram, in which he suggested that we might have to consider the possibility that every species of metazoan had developed independently of all the others from a distinct species of protozoan. The same view was set forth by him in a lecture delivered in Paris on the "Theory of Apogenesis."[2] As the English lecture has not been published I will translate as closely as I can from the French one:

> I do not think it likely that a single substance can have given rise to a general phylogenetic tree according to the classical diagram representing the affinities of species and their distribution in space and time. All the facts would be explained more easily by supposing that there existed, at the beginning, many organized substances developing side by side into species, each of the latter passing through stages more and more advanced without actual relationship of descent between the different species.

Many authors have believed in a multiplicity of the primordial forms of life, but few have suggested an independent origin for grades lower than the main phyla. Przibram, with strict logic, has carried the same reasoning down to the individual species. Most biologists with whom I have discussed the matter refuse to take his suggestion seriously. This, I venture to think, is a mistake. Przibram has simply carried to their inevitable conclusion certain lines of thought that we meet with everywhere in current biological literature; that conclusion is either one of the most significant results of recent biology or it is the *reductio ad absurdum* of much contemporary work.

Geneticists have made us familiar with the doctrine of the inalterability of the gene, with its corollary of evolution by loss of factors, which, by the way, seems to differ little from Przibram's apogenesis. The experimentalists have proved (if it wanted proving) the plasticity of the phenotype, as, for instance, when Przibram himself shows that the length of a rat's tail is a function of the temperature to which the individual and its immediate progenitors have been exposed. As for the inheritance of impressed modifications, the more unequivocal the experiments devised to demonstrate its reality the more clearly do they show it to be of so fugitive a kind as to have no significance in evolution. Paleontologists, as Dr. Bather has told us, have proved beyond the possibility of doubt the occurrence of parallel and even of convergent evolution, without telling us where we are to stop in applying the principle. Many supposed examples of adaptation fail to stand closer scrutiny, and therefore the whole idea of adaptation is declared to be a subjective illusion. All these results at any rate place no obstacles in the way of Professor Przibram's suggestion.

[2] *Rev. Gen. Sci.*, 11 (No. 10): 293, May 31, 1929.

It is to be noted that although the theory of apogenesis is called a theory of evolution it does not deal at all with evolution as that word was used by Darwin. It has nothing to say on the origin of species. On this question it is no more than a doctrine of special creation at one remove. It has no light to throw on classification. If we are to abandon belief in community of descent the whole architecture of the "Systema Naturæ" becomes meaningless.

Professor Przibram claims that "all the facts would be explained more easily" upon his hypothesis, but there is one point on which he speaks with a hesitant voice, and it seems to me a very significant exception. "We can not decide," he says, "whether the differing though related species that inhabit islands or isolated territories are descended from a common source or result from the accidental separation of species which formerly occupied the region together."

Let me recall to you the opening words of the "Origin of Species": "When on board *H. M. S. Beagle* as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to the past inhabitants of that continent." So Przibram ends where Darwin began. The geographical and geological distribution of organisms, which for the one are merely the negligible residue of unexplained facts, were for the other the very heart and core of the problem he set himself to consider.

It is worth remembering that among Darwin's other qualifications as an interpreter of nature he was an experienced taxonomist, and before he wrote the "Origin of Species" he had produced one of the finest systematic works ever written in his "Monograph of the Cirripedia." Those of us who were present at the memorable Darwin-Wallace celebration of the Linnean Society in 1908 remember how the veteran Alfred Russel Wallace discussed "the curious series of correspondences both in mind and in environment" which led Darwin and himself, alone among their contemporaries, "to reach identically the same theory," and how he gave the first place to the fact that both he and Darwin began by collecting beetles and thus acquired "that intense interest in the mere variety of living things" which led them to speculate upon the why and the how of "this overwhelming and, at first sight, purposeless wealth of specific forms among the very humblest forms of life." It might be worth while to inquire whether a training that proved useful to Darwin and to Wallace would not be of some value to students of zoology even at the present day.

My predecessor in this chair told you that "the present position of zoology is unsatisfactory," and he found the chief hope for the future in the application of the experimental method. He may be right. I am not so sure. The experimental method has answered many questions and it will answer many more, but there are some questions, and these well worth the asking, to which experiment will never find an answer. No one will maintain that taxonomy by itself will answer them, but it will often suggest where the answer is to be sought for, and it will provide a standpoint from which both questions and answers will be seen in a true perspective.

Finally, I would recall a remark once made in my hearing by a wise old naturalist, the late Dr. David Sharp. Some one had been remarking on the decline of systematic zoology and predicting the extinction of systematic zoologists. Dr. Sharp replied, in effect:

> I have seen many passing fashions in zoology, many departments of research becoming popular and then falling into neglect; the one branch that will never fail to attract is the systematic one. The esthetic satisfaction to be derived from contemplating the mere variety of animal forms and from tracing the order that runs through all its diversity appeals to a very deep instinct in human nature. There will always be systematic zoologists.

THE USEFULNESS OF PSYCHOLOGY[1]

By J. McKEEN CATTELL

IT is a pleasure to receive this beautiful gold medal of the Society of Arts and Sciences from Mr. Russell, the president of the society, who in its conduct and in other directons has endeavored to bring together the fine arts and the natural sciences. In some of its aspects science is a fine art and both are children of the creative imagination, born with hard labor. As Keats wrote:

> Beauty is truth, truth beauty;—that is all
> Ye know on earth, and all ye need to know.

It is a satisfaction to be introduced by Professor Thorndike, my friend and colleague for more years than he might like me to tell. To him we owe in large measure the present application of psychology to education, the most useful achievement of our science.

It is an honor without parallel to be associated with the earlier recipients of this medal in science, Mr. Edison, Professor Michelson and Dr. Millikan,

[1] Address at a dinner of the Society of Arts and Sciences, the Hotel Biltmore, New York, on the occasion of the award of the medals of the society, April 17, 1930.

three of those to whom America and the world owe the most, and now with Professor Lewis, preeminent in what is perhaps the most fundamental of the sciences.

At the dinner of this society a year ago when its medals were presented to Professor Michelson and Dr. Millikan, Professor Michelson said that he had done his work "for the fun of it" without regard to its usefulness, though he seemed pleased that his superexact measurements of the velocity of light might be applied to topographical surveying. Dr. Millikan, however, chose as his subject "The Economic Value of Michelson." It is on the economic value of psychology, its usefulness to our modern civilization, that I shall speak for the twenty minutes allotted to me. Before an audience of distinction—I assume that the IQ's range from 150 to 200—I wish to urge the need of united efforts to advance psychology and its applications in the interest of all the professions and of our national life.

When an International Congress of Psychology met for the first time in the United States last year, it marked the fiftieth anniversary of our science, for the first laboratory was established by Wilhelm Wundt, professor of philosophy at Leipzig, in 1879. The first professorship of psychology, held by me, was established at the University of Pennsylvania in 1888. When the American Psychological Association was organized in 1892 there were 31 members, not more than half of whom would now be regarded as psychologists. At the recent congress there were in attendance 826 American psychologists each of whom was supposed to have advanced psychology by research. Our science is young; it is growing fast, as youth should. But we have as yet no institutes for psychological research or schools of applied psychology.

The engineers of the country celebrated last week fifty years of progress in mechanical engineering. It is a remarkable record and one to which America has contributed more than its share. The first schools of engineering were established only one hundred years ago; the industrial revolution may be dated from the use of the steam engine of Watts in the coal mines of Cornwall one hundred and fifty years ago; the physical sciences, on which engineering is based, are scarcely older than Galileo, say three hundred years. Physics is six times as old as a science of psychology; it required two hundred years to construct a scientific foundation on which a profession of engineering could be erected.

There was celebrated last week the eightieth birthday of Dr. William H. Welch, of the Johns Hopkins University, who in his lifetime has witnessed and largely contributed to the establishment of a science of medicine. We can scarcely place its foundation earlier than Pasteur, though medical schools go back to the University of Salerno, a thousand years ago. Medicine had to await the development of the biological sciences before an empiric art could become an applied science. As biology is less advanced than physics, so medicine, despite its long history, is on a less secure scientific basis than engineering.

Medicine, law and theology, together with philosophy, were the faculties of the university until engineering emerged a hundred years ago. Teaching is one of the earliest of the arts, but schools of education are only about as old as the present century. Law, the work of the churches, and education are on a less satisfactory foundation than medicine and engineering because there has not been an adequate science of human behavior on which they could be based. It is no less necessary that these professions should stand on a science of psychology than that medicine should stand on biological science, engineering on physical science.

Law and theology, dependent on tradition, precedent, words and an obsolete psychology of property rights and souls, of rewards and punishments, of motives, virtue and sin, are at present in the position of medicine before it had a foundation of science. The story is told of an argument between a judge and a bishop as to whether the courts or the church had the greater power. The judge finally said that the court could condemn a man to death, to which the bishop replied that the church held the keys of heaven and of hell. "That may be," said the judge, "but when I say that a man shall be hanged, he is hanged." But we do not know whether heaven should be promised, and if so to whom, whether men should be hanged, and if so which.

Teaching has done more to adapt itself to modern conditions and to make use of what scientific psychology we have. But human conduct has been altered and controlled by invention and engineering to a far greater extent than by the churches, the schools or the courts of law.

Business and industry are now becoming professions with their own schools, from the commercial high school to the graduate school of Harvard University. These professions, like law, the churches and the schools, are principally concerned with the behavior of individuals and for their development require a science of psychology. The boys who go from college into business far outnumber those who enter any of the older professions or perhaps all of them together. Yet they must develop their own social organizations and athletic competitions as a

preparation, because we have no adequate psychology of conduct that can be used as a basis, in the way that the biological and physical sciences are used for medicine and engineering. Men of business and affairs are psychologists, but in the sense that farmers are biologists, not as physicians are biologists or engineers are physicists.

It may also be that the study and practice of medicine and engineering will be greatly advanced when we realize the extent to which they should be based on understanding and controlling behavior. A painting in the library of the Engineering Society's building in this city bears the inscription: "Engineering—the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race." According to this definition, chosen by engineers, the relations between engineering and psychology are close. The selection, training and directing of men are problems of applied psychology; it is also for psychology to determine what does in fact benefit the human race. In using the forces and materials of material nature engineering has become an exact science; in its relation with human nature engineering works by the rule of thumb and will continue to do so until it can use an exact science of psychology.

The objects of applied psychology, namely, the control of the behavior of individuals, have been advanced by invention and industry to an extent incomparably greater than has been accomplished by psychology, or by the sciences and professions directly concerned with human nature. The applications of science, by quadrupling the wealth that each can produce and by doubling the average length of life, have completely altered our civilization and the way that each of us reacts to it. The economy of labor and of life which science and invention have caused has abolished slavery and serfdom. It has made productive labor by children needless and has made possible their universal education. The wealth of society is now sufficient to support adequately every child, to give it the education that opens the gateway to the career for which it is fit, to provide equality of opportunity and a true social democracy. Applied science, based in large measure on scientific research whose utility was not at the time obvious, has been the cause of the political and social institutions that we have and of the lives that we lead.

The applications of science have done more to control our behavior than efforts made with this object directly in view, such as those of the churches, the schools, the courts and the state. It may be argued plausibly that the ten commandments would have been broken no oftener, that the precepts of the Sermon on the Mount would have been followed no less rarely, if the churches had never existed. It may be that it is as futile to herd children in pens to teach them their R's as it would be to use similar methods to teach them to walk and to talk. It is quite possible that there would be no more crime in the world if courts and prisons had never been invented.

These partial failures to alter human nature by direct appeals to consciousness are quoted to emphasize the thesis that applied psychology is concerned with the total relation of the individual to the environment. We can try to alter the individual; but we can accomplish more by altering the physical world in which he lives, perhaps most of all by altering the relation of an individual to his surroundings. As modern medicine has made more progress in the diagnosis of disease than in its cure, so psychology can determine the intelligence of a child or a congressman more readily than it can increase it. In like manner as medicine and public hygiene can do more for the health of people by providing surroundings that are sanitary than by curing diseases that have been contracted, so psychology can do more by placing individuals in surroundings where they will act in the way that is wanted than by attempting to change individuals, so that under the same conditions they will act in a more desirable way.

The placing of individuals in the situations in which they act in the way most desirable for them and most useful for society is surely an undertaking the value of which can scarcely be overstated. If every one, from the feeble-minded child to the man of genius, were permitted to do the work that he can do best and were trained to do it in the best way, happiness would be increased on a scale for which we have as yet no units of measurement, the annual production of wealth would perhaps be doubled.

But even this story is not the most extravagant that can be told. The selection of existing individuals for the work for which they are best fit is a small matter in comparison with selecting the individuals themselves. Eugenics is at present only an amateur science—Professor Conklin has called it an "infant industry"—but in the distance it looms up in proportions as immense as they are vague. Darwin tells us that when *The Beagle* was visited by South American savages, they showed no curiosity or concern about the ship, but were greatly interested in a rowboat which came within range of their experience. So it is with eugenics—to us as *The Beagle* to the savages—which must be passed with the guess that here the psychological and biological sciences will ultimately find their greatest work.

The control of thoughts, emotions and behavior

has been undertaken by the churches, the schools, the laws and the rest in order to accomplish definite results that are regarded as desirable, but they have largely failed because it is difficult to change human nature. What we can do is determined when we are born; what we actually do depends on circumstance. Individuals at birth have definite constitutions and will react to their surroundings in accordance with them. But we can place them in situations where they will behave as nearly as their constitutions permit in the way that we want. By changing the surroundings we control behavior most effectively. This is what our industrial civilization has done, but it has advanced without special reference to the kind of mental life and behavior that will follow. What we need is a science that will coordinate all efforts to control conduct with the effects of all changes in the environment. This is the primary business of psychology; it requires the cooperation of all the sciences and of all the professions.

As I understand it this medal of the Society of Arts and Sciences has been conferred on a science rather than on an individual. It is a recognition of what psychology has accomplished within a period of fifty years, a mark of confidence in what psychology will do in the future.

OBITUARY

FLORIAN CAJORI

ON August 14, 1930, there died at Berkeley, California, Florian Cajori, the most prolific and best-known writer on the history of mathematics that this country has produced. He was not, however, a native of America, having been born at St. Aignan, near Thusis (Graubünden), Switzerland, on February 28, 1859, and having come to the United States at the age of sixteen. Entering the University of Wisconsin, he received the degree of B.S. in 1883, spending the year 1884–1885 in graduate work at the Johns Hopkins. He then went to Tulane University (1885) as assistant professor of mathematics, becoming professor of applied mathematics two years later (1887). In 1889 he went to Colorado College as professor of physics, subsequently taking the chair of mathematics (1898–1918) and becoming dean of the department of engineering (1903–1918). During all these years he paid particular attention to the history of the subjects of his major interest, and in recognition of his work in this field he was called to the University of California in 1918 as professor of the history of mathematics, a unique title either in this country or abroad. This position enabled him to devote his time largely to research and writing, and the result amply justified the action of the university in creating the position, and his own decision in accepting it.

Forty years elapsed from the date of the publication of his "Teaching and History of Mathematics in the United States" (1890) to the time when death compelled him to lay aside the work which he had hoped to complete—an edition of Newton's "Principia." During these years his contributions to the history of mathematics, physics, geodesy and astronomy were numerous and of increasing value. Besides writing a large number of articles and making a brief excursion into the text-book field, he wrote the following historical works: "History of Mathematics" (1894, with a revised edition in 1919), "History of Elementary Mathematics" (1896, with a revised edition in 1917), "History of Physics" (1899), "History of the Logarithmic Slide Rule" (1909), "William Oughtred" (1916), "History of the Concepts of Limits and Fluxions in Great Britain from Newton to Woodhouse" (1919), "The Early Mathematical Sciences in North and South America" (1928), "The Chequered Career of Ferdinand Rudolph Hassler, First Superintendent of the United States Coast Survey" (1929) and the work by which he will chiefly be remembered—"The History of Mathematical Notations" (2 volumes, 1928, 1929).

It is interesting to see how he developed in the two-score years of his literary activity. His work of 1890, published when he was thirty-one years of age, showed a considerable range of study of source material and a commendable plan of exposition, but it also showed a lack of thoroughness and of finish. His next three books (1894, 1896, 1899) gave less evidence of the study of sources and showed a somewhat excessive dependence upon other writers, notably Gow and Cantor in the case of mathematics. It was not until he was invited to contribute to the fourth volume of Cantor's monumental treatise, the "Vorlesungen über Geschichte der Mathematik" (Leipzig, 1908), that he showed himself in his true light, that is, as an investigator of the history of mathematics whose work was based upon source material. From this time until his death his books displayed this new spirit. His history of the slide rule, though written twenty years ago, still stands as one of our best authorities. This led him to his first important biographical work, the life and labors of William Oughtred, the leading popularizer of mathematics in England in the first half of the seventeenth century. His other venture in the same field, the work on Hassler, may have been prompted by the fact that this leader in establishing

our coast survey was his compatriot, but in any case he succeeded in gathering a considerable mass of material about a man who contributed notably to the scientific work of America. The same spirt of careful research showed itself in his study of the history of limits and fluxions in England and in the investigation of the early mathematical sciences in the New World. By far his best work, however, is his "History of Mathematical Notations," a worthy culmination of his career as a historian. While it is greatly to be regretted that he did not live to publish his edition of the "Principia," he had the satisfaction of seeing this treatise on notations appear in a worthy form and of knowing that the scientific world fully recognized its merits.

His work was not by any means limited to his published books, however. He was a prolific contributor to a large number of scientific journals such as the *Bulletin* of the American Mathematical Society, SCIENCE, the *American Mathematical Monthly*, the *American Journal of Mathematics, Schlömilch's Zeitschrift, Silliman's Journal, The Scientific Monthly, Popular Astronomy*, the *Archivio di Storia del Scienza*, Loria's *Bollettino, Scientia, Bibliotheca Mathematica, Isis, Mathematical Gazette, Popular Science Monthly, School Science and Mathematics* and the *Publications* of the University of California and those of Colorado College. During his years at the University of California he contributed no less than 140 articles and reviews, all of high rank, to these and other periodicals.

His work was duly recognized by learned societies and by various colleges and universities. He was a member of the American Mathematical Society, the Mathematical Association of America, the Deutsche Mathematiker-Vereinigung, the Mathematical Association (England), the American Academy of Arts and Sciences and the American Association for the Advancement of Science, holding offices in at least two of these societies. He was honored by the degrees of Ph.D. (Tulane, 1894), LL.D. (University of California, 1912, and Colorado College, 1913) and Sc.D. (Wisconsin, 1913). As the leading historian of mathematics in this country, his loss will be deeply felt by all who have an interest in this important field of learning.

DAVID EUGENE SMITH

RECENT DEATHS

MR. MICHAEL B. RICH, president of the board of directors of Williamsport-Dickinson Seminary, Pa., was killed in an automobile accident on August 8.

FATHER JOHN GEORGE HAGEN, S.J., director of the Vatican Observatory, died in Rome on September 6 at the age of 83. He was formerly director of the astronomical observatory at Georgetown University.

WILLIAM NELSON REID, for several years metallurgist in charge of the heat treating department of the International Motor Company at Plainfield, N. J., died on September 3.

THE *Electrical World* reports the death in Milan of Professor Francesco Grassi, Italian electrical engineer, at the age of 78. Professor Grassi was one of the Italian delegates to the International Electrotechnical Congress in Chicago in 1893.

Nature reports the following deaths: Dr. Henry Fraser, formerly director of the Institute for Medical Research, Federated Malay States, when he made valuable contributions to our knowledge of beri-beri, bacillary dysentery and leprosy, on July 17, aged fifty-seven years; Mrs. Albert Howard, second imperial economic botanist to the Government of India, who was associated with her husband in the work of the Institute of Plant Industry, Indore, on August 18, aged fifty-three years; His Grace the Duke of Northumberland, K.G., president of the Royal Institution and chancellor of the University of Durham, on August 23, aged fifty years; Professor Conrad von Seelhorst, professor of agriculture in the University of Göttingen, author of "Handbuch der Moorkultur," on July 6, aged seventy-seven years.

MEMORIALS

ON August 17 in the presence of the immediate family of the late Rear Admiral Robert Edwin Peary, U. S. N., and a large number of interested spectators, a boulder, bearing a bronze tablet describing the meridian line marked by Admiral Peary while a resident of Fryeburg, Maine, was unveiled with appropriate ceremony. The meridian has been used by surveyors since then, and is recognized by the United States topographical authorities for its accuracy. The principal speaker was Professor Alfred E. Burton, of Carmel, California, formerly dean of the Massachusetts Institute of Technology. Mrs. Peary unveiled the memorial, and Robert E. Peary, 2nd, spoke of his father.

SCIENTIFIC EVENTS

THE HARVARD SCHOOL OF GEOGRAPHY

ANNOUNCEMENT was made on September 14 by officials of Harvard University of the establishment of a school of geography under the terms of a gift from a Harvard graduate, Dr. Alexander Hamilton Rice, of Newport, R. I., who is an amateur of the geographical

sciences and will serve as the first director of the institution, according to a report in the New York *Herald Tribune*.

The school is the second of its kind in the United States, and its building, which is in process of construction in Divinity Avenue, Cambridge, near the Semitic and University Museums and the University Press, is to be in Georgian style to harmonize with other Harvard structures. The roof will contain a chart house and will be flat to facilitate instruction and practice in field work and surveying. A library with stack rooms for 80,000 volumes, instrument room, drafting room, map room, wireless department and quarters for mathematical and physical geography are included in the plans.

The main objective of the school will be the teaching of the fundamentals of geographical science, with particular emphasis on the position of geography as a science concerned with the study of life and mankind. It will also be occupied with the correlation of the sciences of the biological group, for instructional purposes, with topography and regional geography and the principles of geographical description.

Instruction will be offered in the new auxiliary method of exploration and survey—photography from the air—together with the most approved and up-to-date methods of survey and field astronomy employed in work of an exploratory nature in regional geography. It is planned that the school shall take an active part in geographical exploration on various lines similar to that carried on at the English universities of Cambridge and Oxford.

Harvard officials point out that Cambridge is a particularly favorable location for the institution, since its quarters will be in the center of Harvard's scientific departments, from which every year numbers of expeditions go out to many parts of the earth in search of new material for study.

Dr. Rice has had extensive training and experience in the field of geographical exploration. In addition to his degrees from Harvard College and the Harvard Medical School he has received the diploma of the school of geographical surveying and field astronomy of the Royal Geographical Society and an honorary A.M. degree from Harvard University. He has organized and conducted seven expeditions into tropical South America and has explored, mapped and described an area of more than 500,000 square miles of the Colombian Caqueta, the Brazilian Amazonas and the Venezuelan Guayana.

Dr. Rice is vice-president of the American Geographical Society from which he received the David Livingstone centenary medal in 1920. He is also an honorary corresponding fellow of the Royal Geographical Society, which awarded him in 1914 its Patron's gold medal, and he holds life memberships in numerous scientific and geographical societies of London, Paris, Rome and Madrid.

FALL MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

THE fifty-eighth meeting of the American Electrochemical Society will be held in Detroit, Michigan, from September 25 to 27, 1930, with headquarters and registration bureau at the Hotel Statler.

Registration will begin in the evening of September 24, on the ballroom floor of the Hotel Statler, where the registrar will receive arriving members and guests, distribute badges and programs, and give detailed information. Guests should be introduced by members and when registered may attend the sessions and receive such other courtesies as may be extended to them by the local committee or the officers of the society. Local members of other scientific societies, such as the Associated Technical Societies, the Society of Automotive Engineers, the American Chemical Society, the American Institute of Mining and Metallurgical Engineers, the American Electroplaters' Society and the American Institutes of Electrical Engineers and Chemical Engineers, are invited to register as guests without formal introduction.

All scientific and technical sessions will be held in the small banquet room on the ballroom floor of the Hotel Statler. The informal round table discussion on electric furnace gray iron will be held Friday noon, in the large banquet hall. Dr. Richard Moldenke, noted iron metallurgist, will open the discussion.

The electrochemists will visit the plants of the Ford Motor Company, Parke, Davis and Company, Champion Porcelain Company, Hoskins Manufacturing Company, Ternstedt Manufacturing Company and the General Motors Research Laboratories. By special invitation from Mr. Henry Ford, they will have an opportunity to inspect the Ford Village with its unique collection of old machinery and equipment of great historical interest. Leaving the village, they will adjourn to the airport to witness special stunt flying.

At noon, Thursday, there will be an informal luncheon in the large banquet hall in the Hotel Statler and in the evening there will be a theater party. On Friday evening there will be an entertainment on the Canadian shore.

The following persons will present papers in the order given:

Karl Pitschner, Firestone Steel Products Company; D. L. Hippensteel and C. W. Borgmann, Bell Telephone Laboratories; O. W. Storey, C. F. Burgess Laboratories; E. Newberry, University of Cape Town,

South Africa; O. P. Watts, University of Wisconsin; R. J. Wirshing, General Motors Corporation; H. C. Mougey, General Motors Corporation; A. C. Krueger and Louis Kahlenberg, University of Wisconsin; A. H. W. Aten and Miss M. Zieren, University of Amsterdam; Sherlock Swann, Jr., and E. O. Edelmann, University of Illinois; E. Newberry, University of Cape Town, South Africa; M. deK. Thompson and N. Promisel, Massachusetts Institute of Technology; J. E. Lilienfeld, L. W. Appleton and Wm. M. Smith, The Amrad Corporation, Medford Hillside, Mass; Colin G. Fink and Dwight K. Alpern, Columbia University; G. A. Hulett, Princeton University; V. A. Kostjejev, Zagreb, Jugoslavia; Colin G. Fink and Lawrence Greenspan, Columbia University; Colin G. Fink and Wm. M. Grosvenor, Jr., Columbia University; Carl H. Morken, Detroit Electric Furnace Company; L. E. Stout and Jonas Carol, Washington University; Colin G. Fink and K. H. Lah, Columbia University; W. M. Phillips, General Motors Corporation; Colin G. Fink and F. A. Rohrman, Columbia University; L. C. Pan, College of the City of New York; Edward B. Sanigar, Columbia University; Colin G. Fink and Clarence K. Conard, Jr., Columbia University.

THE AMERICAN PUBLIC HEALTH ASSOCIATION

THE fifty-ninth annual meeting of the American Public Health Association will be held in Fort Worth, Texas, from October 27 to 30. The work of preparing the program of sessions and speakers has been going on for months in the headquarters' office of the association in New York City.

Among the speakers will be the president of the American Public Health Association, Dr. A. J. Chesley, who is also commissioner of health of Minnesota, and Hugh S. Cumming, surgeon general of the Public Health Service of the United States, who succeeds Dr. Chesley as president of the association this year. Other prominent speakers who will address the forty-four sessions and preside at the six symposiums are:

Dr. Shirley W. Wynne, commissioner of health of New York City; Dr. Rafael Silva, chief of the department of public health of Mexico City, Mexico; Dr. Gordon Bates, general secretary of the Canadian Social Hygiene Association, of Toronto; Professor John W. M. Bunker, professor of biochemistry and physiology at the Massachusetts Institute of Technology; Dr. W. A. Evans, director of the health department of the Chicago *Tribune;* Dr. W. H. Ross, president of the New York State Medical Society; Dr. H. W. Schoening, Bureau of Animal Industry, Washington, D. C.; Dr. William C. Hassler, health officer and executive officer of San Francisco; Dr. T. F. Murphy, chief statistician for vital statistics, Bureau of the Census, Washington, D. C.; Dr. John A. Farrell, associate director, international health division, Rockefeller Foundation, New York; Dr. John W. Burns, president, Texas State Medical Association; Dr. James A. Hayne, commissioner of health of South Carolina; Dr. Louis I. Dublin, chief statistician of the Metropolitan Life Insurance Company, New York City; John R. Baylis, filtration chemist, department of public works, Chicago; Dr. C. C. Young, director of the laboratories, State Department of Health, Lansing, Michigan; Dr. Joseph C. Bloodgood, chairman of the Maryland Cancer Committee and an outstanding authority on the prevention and cure of cancer; Professor C.-E. A. Winslow, Yale University; Dr. Aristides Agramonte, professor of bacteriology at the University of Havana; Dr. George W. McCoy, director of the National Institute of Health, Washington; Sally Lucas Jean, health consultant, New York City; Dr. W. M. Dickie, secretary of the California Board of Health; Dr. J. G. Cunningham, of the Provincial Board of Health of Ontario, Canada.

Manufacturers of products and equipment used by public health workers have signified their intention of holding exhibits in the Hotel Texas. In Fort Worth there will be a visit to the water filter plant, the new sewage treatment plant, the various hospitals of the city, the Terrell, Globe and Southwestern Laboratories, which will be of particular interest to physicians and bacteriologists, and several unscheduled trips to the city's health centers, day nurseries and schools.

Following the annual meeting of the association in Forth Worth, there will be a nine-day, all-expense tour to Mexico, allowing five days in Mexico City. This has been arranged for association members and their families, in response to an invitation extended to the association by Dr. Rafael Silva, chief of the department of health of the Republic of Mexico, with the approval of the president of Mexico, to visit Mexico City, to meet the public health workers of Mexico and to participate in a scientific program of interest to the American delegates.

A number of allied organizations have made arrangements to hold their meetings at Forth Worth during the convention of the association; among these are the American Association of School Physicians, the International Society of Medical Health Officers, the Association of Women in Public Health, the Conference of State Sanitary Engineers and the Texas Association of Sanitarians.

FIFTH INTERNATIONAL CONGRESS ON AERONAUTICS

ACCORDING to the New York *Times* a proposal for a permanent international committee on aviation was put forward by Dr. J. A. de Vogel, president of the Dutch Society of Aeronautics, in his presidential address opening the fifth International Congress on Aeronautics at The Hague on September 1.

Dr. de Vogel suggested that such a committee should be instituted to give continuity to the work of aero-

nautic congresses. The first section of the congress studied the problem of the organization of airports and the instruments used in aeronautics, including radio.

The experiences of flying in fog and mist and of ice formation on the wings of planes were exchanged. The number of papers read before the technical sections shows that special importance is attached to information of this sort. In the judicial section questions as to insurance responsibility and neutrality in war were taken up.

Several papers on the influence of flying on the human constitution as studied by physicians were read before the medical section. Air sickness was among the disorders discussed.

The official American observers included Major G. E. A. Reitburg, military air attaché at Berlin, Lieutenant Commander G. D. Murray, naval air attaché at London, and A. D. Douglas Cook, assistant trade commissioner at Berlin, all of whom contributed papers to the congress. There were also present John J. Ide, European technical assistant to the National Advisory Committee on Aeronautics; Professor Alexander Klemin, of the Guggenheim Foundation; Dr. W. G. Friedrich, research engineer of Hackensack, N. J., and Clarence M. Young, who addressed the congress on American airway practices.

Sir Sefton Brancker, air vice marshal, headed the official British delegation, which included eight officials of the British Air Ministry.

In the first section of the congress discussion centered on the best way to light air routes and the value of neon light for this purpose. This discussion followed the general lines of the resolutions adopted by the Berlin conference last April. Proposals to be made at the International Congress for Safety in the Air, which will meet in December, were examined, and a small editorial committee will formulate some amendments.

In the medical section standard nomenclature was advocated and discussed, and remedies in regard to sickness among aviators were considered. The air tourist section resolved to formulate a requirement that every town of 10,000 inhabitants shall in some way make its name visible to aviators in flight.

In the judicial section a resolution proposed by a Polish delegate was adopted providing that international conventions on the responsibility of passenger services for the lives of passengers can have no practical effect as long as they are not supplemented by the obligation of air services to insure the lives of passengers up to a maximum of 125,000 francs (about $5,000). This is designed to increase safety measures on the part of air services.

The Italian under-secretary of aviation, Signor Fiannini, proposed a resolution that the unification of laws in aeronautical matters should be furthered as much as possible. The technical section decided to treat meteorological subjects in a special committee of experts, who will meet under the chairmanship of the director of the official Dutch meteorological institutes.

GEOLOGIC SURVEY OF GEORGIA

MR. S. W. MCCALLIE, state geologist of Georgia, has announced the beginning of a survey that will require several years for completion and will give Georgia its first complete geologic map, according to a report in the *U. S. Daily*.

Several sectional maps have been made from time to time in Georgia, but the state has lacked a general and comprehensive chart of its geological resources.

Dr. G. W. Crickmay will be in charge of the survey in northern Georgia and Dr. W. S. Bailey, of the University of Illinois, has been retained to assist Dr. Crickmay.

In the southern part of the state, Dr. C. Wythe Cooke, of the United States Geological Survey, will complete this season a map showing the exact location of all classes of rocks and minerals in that section. This work will be coordinated with that in other quarters of the state in compiling the complete chart.

The last available report of commercial minerals in Georgia showed a total value of $16,683,011 for the year 1928, with brick and tile leading in the value of production, and marble and granite next in order. Other valuable minerals listed are bauxite, cement, clay, fullers' earth and manganese.

SCIENTIFIC NOTES AND NEWS

DR. FRANZ BOAS, professor of anthropology at Columbia University, has been elected an honorary member of the Wurzburg Geographical Society.

THE French Astronomical Society has decided to award a medal of honor to the Lowell Observatory at Flagstaff, Arizona, as an expression of appreciation and admiration for the discovery recently made by the observatory of the trans-Neptunian body, preparation for which was made by the learned research of Mr. Lowell.

DR. FRANCIS PENDLETON GAINES, formerly president of Wake Forest College, will be inaugurated as president of Washington and Lee University on October 25.

AMONG the honorary degrees conferred by the University of Liverpool were the following: doctor of laws, Mr. R. L. Mond, honorary secretary to the Davy-Faraday Research Laboratory of the Royal Institution; doctor of science, Professor G. Barger, professor of chemistry in relation to medicine in the University of Edinburgh.

DR. J. S. PLASKETT, director of the Dominion Astrophysical Observatory, has returned to Victoria after a trip through the United States and to England, during which he received the Rumford Medal and the medal of the Royal Astronomical Society.

DR. HANS SACHS, professor of immunology at Heidelberg, and Dr. Ernest Meinicke, of Hagen, Westphalia, have been awarded the Ludwig-Darmstädter Prize with the Paul Ehrlich medal.

THE Bruce Prize of the Royal Society of Edinburgh for the period 1928–30 has been awarded to Mr. N. A. Mackintosh for his researches into the biology of whales in the waters of the Falkland Islands Dependencies. This prize is awarded by a joint committee consisting of representatives from the Royal Society of Edinburgh, the Royal Physical Society and the Royal Scottish Geographical Society.

DR. JEAN CHABRY, Paris, who lost his right arm as a consequence of his early work in radiology, has received the Cross of the Legion of Honor.

M. J. REY has been elected a member of the Paris Academy of Sciences.

PROFESSOR WILLIAM H. WELCH, of Johns Hopkins University, has been elected an honorary member of the Berlin Medical Society.

MR. G. A. SUTHERLAND, principal of Dalton Hall, University of Manchester, and special lecturer in physics in the university, has been invited to be president of the section of acoustics at the twelfth International Congress of Architects at Budapest next September.

DR. F. H. EWERHARDT, of Washington University, was elected president of the American Congress of Physical Therapy for the year 1931–32. Dr. Gustave Kolischer, Chicago, was elected first vice-president; Dr. Luther A. Tarbell, New Haven, second vice-president, Dr. J. S. Hibben, Pasadena, third vice-president, Dr. F. H. Morse, Boston, fourth vice-president, Dr. F. L. Wahrer, Marshalltown, Iowa, secretary, and Dr. John S. Coulter, Chicago, treasurer.

ON September 13 the Reverend Aloysius J. Hogan became president of Fordham University to succeed Reverend William J. Duane, who on July 30 completed his term of six years as the head of the university.

CANON PIERRE DE STRUYCKER, president of the College of Pope Adrian VI, Brussels, is named to be rector of the American College at Louvain, where he was formerly vice rector. He succeeds Monsignor de Becker, who retired after fifty years as a professor.

PROFESSOR C. FLOYD JACKSON, professor of zoology at the University of New Hampshire, has been named dean of the college of liberal arts at the university by President Edward M. Lewis and will assume his new duties immediately. He succeeds Albert N. French, who resigned as head of the college last spring to devote all his time to his work as professor of sociology.

THE school of engineering of the Pennsylvania State College announces that Professor Fred C. Stewart, of the Georgia School of Technology, will take charge of the mechanical laboratory in place of the late Professor C. C. Cochran.

THE new Brooklyn College, which combines the borough's branches of the City College of New York and Hunter College, will open in the near future, with Dr. William A. Boylan, formerly associate superintendent of schools, as president, and Dr. Adelbert G. Fradenburgh as dean of the college. Evening classes will be divided in two divisions as follows: Meta E. Schurtz, assistant director, will have charge of the women's division and James W. Park, also an assistant director, will be in charge of the men's division.

THE following new appointments have been made at Drexel Institute: Mr. Walter Lord Obald, formerly research associate for the Marine Underwriters at the Department of Agriculture, has been appointed assistant professor of biological science; Mr. William E. Mann, instructor in mathematics, and Mr. H. P. Simons, instructor in chemistry.

DR. SAMUEL GELFAN, formerly research fellow in physiology at the University of Chicago, has become assistant professor of physiology and pharmacology at the University of Alberta in Canada.

A. P. BJERREGAARD, until recently chief chemist for the Empire Refineries Division of Cities Service Company and lately doing consulting work, has been appointed professor of chemistry and dean of the science department in the Bryan Memorial University, Dayton, Tennessee.

ALBERT B. STEVENS has become a member of the faculty of the University of Southern California as instructor in general engineering.

DR. KIMBALL YOUNG and Dr. Ralph Linton, formerly associate professors of sociology and social anthropology, respectively, at the University of Wisconsin, have been promoted to full professorships.

ACCORDING to *Nature* the following appointments have been made: At the University of Aberdeen, Dr. James Ritchie, keeper of the natural history department of the Royal Scottish Museum, Edinburgh, to be Regius professor of natural history in succession to Professor J. Arthur Thomson, and Dr. David Campbell, Pollok lecturer in pharmacology and therapeutics in the University of Glasgow, to be Regius professor of materia medica in succession to Professor C. R. Marshall; Dr. R. T. Dunbar, lecturer in physics, to the chair of physics at the University College of South Wales and Monmouthshire, in succession to Professor H. R. Robinson, who has been appointed professor of physics at East London College (University of London), and Dr. John Walton, lecturer in botany in the University of Manchester, to be Regius professor of botany in the University of Glasgow in succession to Professor J. M. F. Drummond, whose resignation takes effect on September 30.

PROFESSOR HENRI ROGER, dean of the Paris School of Medicine since 1912, having retired from active duty on account of age, the council of the faculty has elected as his successor M. Balthazard, professor of legal medicine and director of the medicolegal institute. He received thirty-four votes as against thirty-three cast for M. Roussy, professor of pathologic anatomy and director of the Cancer Institute. The appointment is for seven years.

PROFESSOR V. C. FINCH, professor of geography at the University of Wisconsin, has been appointed a member of the geography division of the National Research Council's science advisory committee.

DR. COOPER CURTICE, veteran parasitologist of the Bureau of Animal Industry, retired from the service on August 31, at the age of seventy-four years.

DR. MALCOLM H. SOULE, associate professor of bacteriology at the University of Michigan, has spent the summer in Europe as United States delegate to the International Congress of Microbiologists at Paris and guest of the Hygienic Institutes at Prague and Warsaw.

DR. ALEXANDER MEIKLEJOHN, chairman of the experimental college at the University of Wisconsin, has been appointed one of the nine American delegates to the International Congress of Philosophers at Oxford.

PROFESSOR PAUL M. LINCOLN, director of the School of Electrical Engineering of Cornell University, has returned to Ithaca from a trip around the world, during which he attended the World Engineering Conference at Yokohama and the World Power Conference at Berlin.

THE following American chemists were appointed by the National Research Council to attend the tenth meeting of the International Union of Pure and Applied Chemistry which was held at Liége, Belgium, from September 14 to 20. Councilors were appointed as follows: Charles L. Reese, consultant, E. I. du Pont de Nemours and Company, Wilmington, Delaware, *chairman* of the delegation; Edward Bartow, professor of chemistry and chemical engineering, State University of Iowa, Iowa City, Iowa; Marston T. Bogert, professor of organic chemistry, Columbia University, New York City; James B. Conant, professor of chemistry, Harvard University, Cambridge, Massachusetts; Austin M. Patterson, professor of chemistry, Antioch College, Yellow Springs, Ohio; Claude S. Hudson, professor of chemistry, U. S. Hygienic Laboratory, Washington, D. C. The following delegates were appointed: C. A. Browne, assistant chief, U. S. Bureau of Chemistry and Soils, Washington, D. C.; J. V. N. Dorr, president, Dorr Company, 247 Park Avenue, New York City; John B. Ekeley, professor of chemistry, University of Colorado, Boulder, Colorado; Gustavus J. Esselen, research and development chemist, Boston, Massachusetts; William Lloyd Evans, professor of chemistry, Ohio State University, Columbus, Ohio; Joel H. Hildebrand, professor of chemistry, University of California, Berkeley, California; J. R. M. Klotz, American Cyanamid Company, 535 Fifth Avenue, New York City; G. M. Norman, technical director, Hercules Powder Company, Inc., Wilmington, Delaware; Alexander Silverman, professor of chemistry, University of Pittsburgh, Pittsburgh, Pennsylvania. Dr. Esselen was also appointed by the council to attend the tenth Congress of Industrial Chemistry held at Liége from September 7 to 13.

THE nineteenth Italian congress for the advancement of science opened at Bolzano, Italy, on September 7. The inaugural address was delivered by Professor Pietro de Francisci. The congress continued until September 10, when it was transferred to Trento, where Guglielmo Marconi made the inaugural speech on "Phenomena Accompanying Radio Transmission." A number of government ministers, including the secretaries of agriculture and of corporations, read papers.

HAMBURG was host from September 7 to 15 to the twenty-fourth International Amerikanisten Congress, members of which are students of all that pertains to America, its history, political and historical, geography, geology, archeology and culture, or research workers in these fields. The following are the most important subjects considered: "The American Indian and His Relations to Other Americans"; "Customs and Habits of the Indians, Their Origin and Extension in the Old and New World"; "The Language of the American Indian, Beginnings of American History. With Especial Consideration of

the Time of Discovery and the First Settlers"; and "Geographical and Geological Problems in Connection with Man's Work." "The Culture of the Indians before Their Contact with Europeans and in the Present" was the main subject of discussion of the congress under the leadership of Professor Dr. Sapper, Wurzburg. The congress will meet in Buenos Ayres in 1932.

THE work of the Philippine Bureau of Agriculture, for the past thirty years charged with the regulation and promotion of agricultural industries in the Philippines, according to the *Experiment Station Record*, has been divided into two parts and assigned to bureaus of plant industry and animal industry. Dr. Manuel Luz Roxas, head of the department of agricultural chemistry of the Philippine College of Agriculture, a 1911 graduate of this institution and a recipient in 1917 of the Ph.D. degree from the University of Wisconsin, has been appointed director of the Bureau of Plant Industry.

DISCUSSION

THE NEED FOR AND THE PROPOSAL OF A NEW GENETIC TERM

A PHASE in the development of genetics which is just getting under way is the analysis of genetic effects over the range of a controllable variable. The data on the effects of temperature upon facet number in the bar series of Drosophila may be quite satisfactorily fitted to the equation $y = ae^{rt}$, in which r is the relative rate of change; t, the temperature in degrees Centigrade; e, the base of the natural logarithms, and a, a constant which gives the value of y, that is, the number of facets when $t = 0$. The first derivative is given by the equation $\frac{dy}{dt} = yr$. Its value at 15° for reverted full females is -21.51 facets. Similar values for bar, ultra-bar and infra-bar females are, respectively, -12.66, -3.76 and $+8.48$ facets. It is held that such values form a better basis for the characterization and analysis of the genetic differences than average facet number, since they take into account at one and the same time not only the number of facets but also the relative rate of change with respect to temperature. From an analysis of the bar series in terms of the first derivative of facet number with respect to temperature new and interesting relations emerge.[1] The point at present, however, is that in such analysis the need is felt for a new term—one to refer to the first derivative of the phenotypic quantity (in this case, facet number) with respect to the controllable variable (temperature).

In analyzing some data on the effect of temperature upon wing-area in homozygous and heterozygous vestigial females it is found that the same equation applies. The value at 30° of the first derivative of wing-area with respect to temperature for long-winged females is -0.0564; for long × vestigial females, -0.0501, and for vestigial females, $+0.0112$ sq. mm. As in the case of the facet-temperature relation, one requires here a term to refer briefly to the first derivative of the wing-area with respect to temperature. As soon as one attempts to speak about the first derivative of such quantities a need is felt for a simple general term.

The convenience and value of a general term for such quantities is well demonstrated by the special terms used for designating the derivatives of various physical quantities with respect to an independent variable, among which may be recalled velocity, acceleration, current, specific heat, modulus, pitch.

In a conversation with Mr. Francis S. Haserot during which several possibilities were discussed he suggested that it might be well to reduce pheno-derivative (abbreviation for phenotypic derivative) simply to *phene*. The following considerations seem to indicate—if the need for such a term be granted—that the situation is perhaps adequately met by the term *phene*. (1) Its relation to the phenotypic expression of the genetic constitution is sufficiently obvious. (2) The nature of the independent variable may be readily indicated by the use of a suitable adjective or prefix, *e.g.*, *thermophene*. (3) That it is but one syllable readily allows for its use in compounds as occasion should arise. Bar facet-thermophene and bar bristle-thermophene clearly distinguish the first derivative with respect to temperature of two different phenotypic quantities on which the bar gene produces an effect. (4) The proposed term allows easy reference to the two related quantities, the first derivative and the original quantity. The inverse of the derivative is the anti-derivative, hence *anti-phene*. For example, the phene for reverted full at 15° is -21.51 facets, and the corresponding anti-phene is 935.4 facets. (5) The word *phene* is not preoccupied, although it happens to be an obsolete chemical term. (6) It is free from any indication of a theoretical interpretation regarding how the genetic factors produce their effects.

In conclusion, the term *phene* is proposed as a word to refer to the first derivative $\frac{dy}{dx}$, in which y is a phenotypic quantity, and x an independent variable. The economy of expression attained by the use of this

[1] A. H. Hersh, "The Facet-temperature Relation in the Bar Series of Drosophila," *Jour. Exp. Zool.* (in press).

term may be indicated as follows: the cumbersome phrase, "first derivative of a phenotypic quantity (facet number, wing-area, etc.) with respect to temperature" is replaced simply by "thermophene."

A. H. HERSH

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THE DETERMINATION OF CARBONATES IN SOIL

IN a recent issue of SCIENCE[1] Schollenberger discusses briefly the error obtained in the determination of carbonates in soil when a strong acid is used as the decomposing agent. He recommends the use of dilute acid and ferrous chloride at a low temperature.

The writer experienced similar difficulty several years ago in the analysis of some Illinois soils.[2] When using 1:1 hydrochloric acid in the Parr apparatus carbon dioxide was obtained from several soils distinctly acid in reaction. Similar results were obtained with sulfuric and phosphoric acids. Nor was the difficulty overcome when the decomposition was carried out at room temperature under reduced pressure. It occurred to the writer that possibly a weak acid should be used in preference to a strong one. Acetic acid was tried with success, no carbon dioxide being liberated from non-carbonate containing acid soils, and in the case of soils containing carbonates a lower value being obtained, the difference being consistent with the amount of carbon dioxide previously found in acid soils when a strong acid was used. No study was made of the causes of the error obtained with strong acids, but it was observed that the error appeared to be independent of the organic matter content of the soil.

Glacial acetic acid diluted 1:1 or 1:2 is used, no other modification in the procedure described by Hopkins[3] being necessary.

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MUSICAL PITCH AND THE PHYSICISTS

I THINK it is time to bring forward once more the desirability of a reform which has long been overdue. I refer to the absurd and unnecessary discrepancy which exists between the usages of the physical and of the musical worlds in the important matter of standard of musical pitch.

For a long time it has been the custom of physicists to make use of a standard of musical pitch based upon a frequency of 256 double vibrations per second for the note middle C, which stands number 40 on the piano keyboard. This frequency actually, however, is rather more than 6 vibrations per second lower than the actual standard frequency of the same note as now universally adopted throughout the United States and in most parts of the civilized world. This latter pitch is usually known as the A440 pitch; that is to say, it is based upon a frequency of 440 D.V.P.S. for the note A which stands number 49 on the piano keyboard. This pitch, or something extremely close to it, has been adopted by virtually all the symphony orchestras of the world, and in consequence by nearly all other musical practitioners, save in France, where the standard still remains the French "normal diapason" of 435 for the same note.

In 1918 the American Federation of Musicians adopted the A440 pitch. In 1925 a committee of the Music Industries Chamber of Commerce, of which I was secretary, representing the manufacturers of every type of musical instrument made in the United States, including the associations of piano, of organ and of wind instrument manufacturers, unanimously recommended that the A440 pitch, based upon a standard tuning fork giving this pitch at a temperature of 68° Fahr., should henceforth be the standard pitch for all musical instruments made in this country. The recommendation was adopted by the directors of the chamber. So far as I know, every manufacturer of pianos, of organs, of wind and of brass instruments in the United States is at this moment using this pitch, which in point of fact represents more nearly than anything else the prevailing standard throughout the world.

As can readily be seen, the discrepancy between this pitch and the entirely artificial pitch used by physicists in their acoustical work becomes extremely serious in the higher regions of the musical scale. Thus, for instance, the note which is represented by 440 D.V.P.S. on the standard scale above mentioned stands at 430.5 on the physicists' scale. In the higher regions the discrepancy is extremely noticeable. Thus, when I sound a fork made on the physicists' scale for the high C, which stands number 76 on the piano keyboard, and compare its sound with that of the same C on our Steinway grand, which is always kept carefully tuned to the 440 standard, the flatness of the tuning fork is extremely obvious and unpleasant, for, as can readily be seen, there is a difference of no less than 44 double vibrations per second. I assume, of course, in both cases, the universal equal tempered systems of tuning.

Instances might be multiplied, but what I have

[1] SCIENCE, 72: 13–14, July 4, 1930.
[2] *Soil Science*, 28: 149, 1929.
[3] C. G. Hopkins, "Soil Fertility and Permanent Agriculture," p. 628, 1910.

said should be sufficient to exemplify the absurdities of the situation. Since the advent of radio engineering and the consequent revival of interest in matters musical among physicists and electrical engineers, the existence of a discrepancy like this becomes extremely important. In most of the scientific papers dealing with acoustical matters in which questions of pitch are taken up, the physicists' scale is used. One is driven to the conclusion that many scientific men are unaware that the scale which they are using is completely artificial and is nowhere used for the practical performance of music.

In matters relating to hearing, to levels of sensation, to discrimination of pitch and to the investigation of musical esthetics, it is obviously essential that all parties to such investigations should speak the same language. It is unfortunate that scientific men and musicians should seem to feel a sort of mutual antagonism, but the fact that their interests are now forcibly merged one with the other ought to bring about some sort of an "entente cordiale" between them. Such consummation is devoutly to be wished for the best interests of the new science of acoustics and for the big practical interests of the recording and reproduction of music. There is not the slightest excuse, save arithmetical convenience, for the persistent use by physicists and engineers of a scale that has not been used for the practical performance of music since the time of Handel. It is high time that when one reads in a scientific paper something about a certain musical note, one should be able to be sure that the writer of the paper means in sound what a pianist, violinist or clarinetist playing that note would actually evoke from his instrument.

I am not alone in the pleas expressed here. Dr. Dayton C. Miller, one of the greatest of American pioneers in the science of musical acoustics, long since called attention to the absurdities which I have ventured to describe once more. In his book "The Science of Musical Sounds," published in 1916, he devotes some space tc the discrepancy mentioned, and makes a plea for uniformity and common sense.

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PHYSIOLOGY OF RARE GASES

IT is to be hoped that the article of Professor Hershey in SCIENCE of April 11 last on the "Components of Air in Relation to Animal Life" will command some attention. The idea that the rare gas fraction of the atmosphere has some physiological significance has had a great attraction for me during the past ten years, and as far as my acquaintance with the literature goes, Professor Hershey's work is outstanding in its direct bearing on the subject. The experiments of McDonald and Kellas,[1] Kellas,[2] Tolomei,[3] Regnard and Schlösing,[4] Zaleski,[5] Marcacci,[6] Cannon and Free,[7] Pictet, Scherrer and Helfer[8] and Hackspill, Rollet and Nicloux[9] when taken together have given no decisive answer to such a question.

In describing the results of experiments with nitrogen-oxygen mixtures, Professor Hershey was led to remark that "the rare gases seem to play a part in normal life equally as important as oxygen." On the other hand, when in the nitrogen-oxygen mixtures the latter gas was increased to a proportion of from 25 to 40 per cent., "the animals appeared to be normal and in a few cases better than in normal air." This leads to an inference that an apparent compensation for the absence of the rare gases was accomplished by an increase in oxygen and reciprocal decrease in nitrogen within certain limits.

Since in the complete absence of oxygen the duration of animal life is only a matter of minutes, while in certain mixtures of nitrogen and oxygen with an absence of the rare gases the duration was at least three weeks, the importance of these rare gases does not appear to be vital in the absolute sense unless a longer period of time is required for the demonstration. It may be, therefore, that we are presented with an analogy to the food requirements of the animal organism, where the bulky part or roughage corresponds with the nitrogen, the caloric value with the oxygen and the accessory food factors with the rare gases. Vitamin deficiency takes a much longer time to injure health and end life than the complete withdrawal of food. It may be possible too that the food is itself a means of compensation or source of error, for Tolomei's contribution to the problem was to show that argon is locked up in the root tubercles of legumes which are associated with nitrifying bacteria. In judging of a state of health that is "better than normal," general appearances must be considered, but without some quantitative guide, such as size and weight or rate of growth of the young, one must be wary. The slight flush and bright eye of a low fever may improve the appearance of the human being though he be impaired in health.

1 "The Gases of the Atmosphere," Ramsay.
2 *Proc. Roy. Soc.*, 59: 66.
3 Chem. Cent. I, 1030 (abstract).
4 *C. r. Acad. Sci.*, 124: 302.
5 *B. Dtsch. Chem. Ges.*, 30: 965.
6 *Mem. R. Ist. Lomb. Sc. e Lett., Sc. Mat. e Nat.*, 19–20, Ser. 3.
7 Carnegie Inst. Yr. Bk., 20, 63.
8 *Helv. Chim. Acta*, 8: 537.
9 *C. r. Acad. Sci.*, 182: 719.

It is evident that long-continued experiments may be necessary, and in the case of specific mixtures of gases requiring the complete absence of the rare gases or their presence in definite proportions, the apparatus may become complicated and the technique very exacting, especially when any record is to be kept of metabolic changes. For some purposes a closed circuit is a necessity, and I am not sure but that such a system introduces some complicating conditions, possibly by gas adsorption upon walls or materials or by the cutting down of radiant energy from without. In my own efforts,[10] for example, results soon led from experiments with nitrogen-oxygen mixtures to a closer examination of what happened to animals when confined in a circuit of ordinary air. Frogs were the most convenient animals to use, and there was disclosed a peculiar fluctuation in the nitrogen-rare gas fraction of air which was apparently correlated with light and darkness.

It is the relative proportions of the various gases in an atmosphere that seems to me to be a matter of prime importance, and this is clearly indicated in Professor Hershey's experiments. The necessity for accurate gas analysis led me to discontinue respiration experiments in 1924 in order to develop an apparatus for the analysis of air samples in which the "inert" fraction could also be determined. As soon as attempts were made to increase accuracy, irregularities began to appear with such persistence that it seems possible that differences as low as .01 per cent. in oxygen estimations may have some significance other than technical error. The associated gases may, perhaps, play some part, for irregularities tended to be greater when using oxygen made by the liquid air process where the argon impurity was about 1.9 per cent. Results are still very confusing, but an anomaly seems to be developing which must be more clearly defined before reporting. That these irregularities are due to an isotope may be possible. The magnitude of change is such as to be perhaps too frequently ascribed to experimental error and on that account keeps the observer in a harassed state of mind.

The main object of this note is to give a word of praise and encouragement for these experiments of Professor Hershey. One of the chief difficulties in arousing interest in and support for such work is to present any reasonable mechanism by which the "inactive" gases may act upon the body. The possibility of finding a mechanism in the field of gas analysis has kept me away from the more physiological type of respiration experiment. While medical men may understand little concerning the rare gases, as Professor Hershey suggests, I have a suspicion that the chemist and physicist are likewise ignorant of some important relation between these noble gases and the commoner constituents of the atmosphere.

EDWARD FIDLAR

[10] Univ. Toronto Studies, Physiol. Series No. 98.

SCIENTIFIC BOOKS

Manual of Meteorology, Vol. III. *The Physical Processes of Weather*. By SIR NAPIER SHAW, F.R.S., sometime director of the Meteorological Office, London, and president of the International Meteorological Committee. With the assistance of Elaine Austin, formerly of Newnham College, Cambridge. Cambridge University Press. American agent, Macmillan. 445 pages, 149 figures. Price $9.00.

THIS being an air-minded (not *aero*-minded) age with airports (not *aero*ports) and aviation instruction schools advertised by every ambitious town, we would expect to find airgraphics (not *aero*graphics) holding a prominent place in the curricula of our colleges and universities. Such is far from reality. Worse yet, no one feels responsible. Physicists are indifferent; engineers, not excluding aeronautical engineers, feel it is not up to them; chemists, biologists, geologists and even economists give themselves no concern, content perhaps with a daily weather map. Yet in every field of scientific endeavor, varying atmospheric conditions have direct and noticeable effects. We do not see how precise measurements, for example, can be made when only casual uncorrected readings of pressure and temperature are made.

By airgraphics we mean just what the word says, the science of the air, the description in full of atmospheric phenomena. It is more than the physics of meteorology, or the statistical methods of climatology, being in brief the detailed study of the earth's gas envelope, regarded as a tremendous thermal engine, with energy transformations of heat and motion. Sir Napier Shaw, retiring from a long and proved leadership of the Meteorological Office, set himself the heavy task of collating all that had been done in atmospheric physics and dynamics by divers workers in many lands, and seen from different angles. This has long been miscalled meteorology. (In the present volume [III] meteors are mentioned twice. In Vol. II there are two scant references, and in Vol. I, one.)

Vol. I, it will be recalled, gave a general survey of the atmosphere; Vol. II dealt with the physics of the air. The present volume (III) sets forth the dynamics and thermodynamics of circulation. Vol. IV has had a curious history, illustrating that the last shall be first, for it was issued in 1919 and dealt with the wind

as connected with pressure distribution. We are given to understand that a new Vol. IV is on the stocks, for the double reason that the first issue is already out of print and that there is so much to be added.

Individual effort could hardly accomplish such monumental work and Sir Napier acknowledges fully the ready cooperation of many former official associates, and others, not forgetting proof-readers, pressmen, binders and the manager of the University Press. We take it that all felt a measure of pride in the making of these volumes.

There is not space here to discuss at length new material. One matter of great moment is the practical application of entropy—that elusive something connected with the degradation of heat which college instructors despair of ever explaining lucidly to their classes. It is here regarded as "an index of the dilution of the energy of the working air." In fact, the whole of Chapter VI, treating of "Air as Worker," is a piece of straight thinking on a difficult subject. His tephigram (a combination of temperature and entropy) enables one to plot the heights of successive isentropic surfaces. We are given tables for calculating the entropy of the air, when temperature and pressure are available. We can now regard "an *isentropic surface* as a practical alternative for sea-level or some other *horizontal* surface on which to place the facts about the weather."

Sir Napier of course is a master hand at good English. The nine-page comment on the analogy of medicine and meteorology could well be reprinted as a separate, making a delightful little essay requiring only fifteen minutes to read, but inspiring hours of thinking over. A few lines will make this clear.

> We might indeed have profited by the analogy to which we have drawn attention by giving to this volume the title "The Physiology of Weather," as defining the attitude which meteorologists have to adopt towards experimental physics. We have felt however that to do so might convey the impression that we were proposing to regard weather as the expression of a living organism. Although the weather has many characteristics that are suggestive of vitality, we have thought it best to avoid that impression.

Any forecaster of long experience will appreciate the implication that the weather has a will of its own and like old Joey is deep and devilish sly!

And acknowledging the impeachment that he is not a text-book writer, *i.e.*, one who saves students the trouble of thinking, it is suggested that comprised within the almost unpronounceable name of meteorology there are a large number of subjects quite worth while thinking about. It is in a way unfortunate that the science has been to some extent accepted as a responsibility of government, and this perhaps accounts for much of the indifference of universities, as mentioned above.

It only remains to say that we wonder why a Nobel prize has not come to Sir Napier Shaw. We hope that such recognition will not be much longer withheld.

ALEXANDER MCADIE
BLUE HILL OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE RATE OF GROWTH OF STALACTITES[1]

IN the summer of 1929 the writer observed stalactites suspended from the roof of the inspection tunnel in the Wilson Dam at Muscle Shoals, Alabama, and later a series of specimens was collected for him by Captain H. D. W. Riley, of the Corps of Engineers. These stalactites are of more than ordinary interest, as their age is known and their rate of growth can be approximately determined.

Fig. 1 is a generalized sketch section of the Wilson Dam. The inspection tunnel is near the base of the dam on the upstream side, its floor 90 feet below the surface of the impounded pool. It is 6 by 9 feet in section and 4,600 feet long. In it are located the valves of the wells for the relief of accumulated hydrostatic pressure in the bedrock beneath the dam. The stalactites hang from the roof of the tunnel along the lines of junction of adjacent concrete segments.

[1] Published by permission of the director of the U. S. Geological Survey.

Most of the stalactites ranged between 5 and 9 inches in length (12.7 and 22.8 centimeters) and the

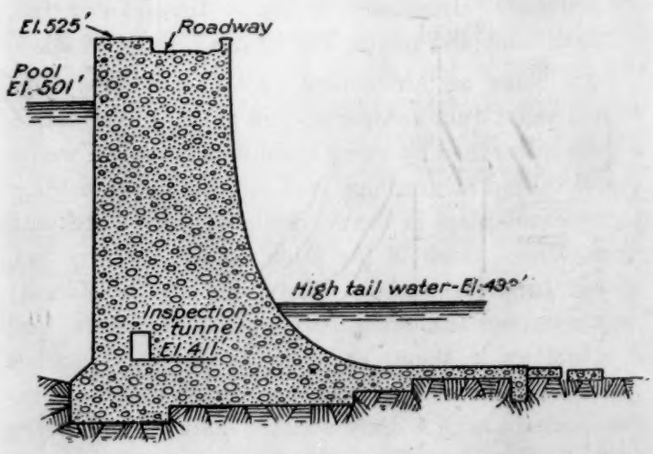

FIG. 1. Cross-section of Wilson Dam at Muscle Shoals, Alabama. The stalactites hang from the roof of the inspection tunnel, eighty-one feet below the surface of the pool.

longest observed was 15.2 inches (38.7 centimeters). The average diameter near the tip was 0.2 inch (0.5 centimeter), and at the base the diameter ranged between 0.5 and 1.5 inches (1.2 and 3.8 centimeters). All had the form of hollow cylindrical tubes whose walls increased in thickness from the tip toward the point of attachment. With two or three exceptions the stalactites were symmetrical.

Impounding of the reservoir was accomplished early in 1925, and the stalactites were measured early in 1930 so that their present size represents five years' growth. Roughly the linear growth rate of the average specimens was between 1 and 2 inches a year. As pointed out by Allison,[2] the factors affecting stalactitic growth are rate of drip, air circulation, relative humidity, temperature and concentration of the mineral content of the water. As each of these factors has a wide range in different places, it is obvious that the rate of stalactitic growth in the Wilson Dam inspection tunnel is peculiar to the exact conditions there prevailing and is not generally applicable.

Recently Mr. F. E. Matthes, of the U. S. Geological Survey, showed the writer a tubular stalactite 3.5 inches (8.9 centimeters) long, 0.5 inch (1.3 centimeters) in diameter at the base and 0.25 inch (0.6 centimeter) at the tip, which he had collected from the arch of a concrete culvert in Rock Creek Park in Washington. The culvert was constructed in 1927, and the stalactite had attained the dimensions given two years later.

In connection with the stalactites already described two exhibits at the National Museum are of interest. One (U. S. N. M. No. 39089) is a group of tubular stalactites 0.5 inch (1.3 centimeters) in diameter and 4 inches (10.2 centimeters) long, which were formed under one of the old arches at the west side of the center of the Capitol. Although the time of formation is not exactly known, it is on the order of tens rather than hundreds of years.

A second exhibit (U. S. N. M. No. 68342) is a pint whisky bottle which was left for five years under a small drip in Weyers Cave, near Shenandoah, Virginia. The bottle is coated with a crust of calcium carbonate which has a maximum thickness of 0.25 inch (0.6 centimeter).

Allison[2] noted stalactites in a coal mine growing at the rate of 0.1 to 1.44 centimeters in length a month. Curtis[3] observed aragonite aggregates growing in drops of water at the rate of $\frac{3}{8}$ inch in three months.

Mr. E. T. McKnight,[4] of the U. S. Geological Survey, observed calcium carbonate stalactites as much as 2 feet in length and several inches in diameter suspended from old timbers in a lead mine in Arkansas. The maximum age of these stalactites is probably 30 years.

The observations cited indicate that the formation of stalactitic and stalagmitic deposits of calcium carbonate in caves can proceed at a fairly rapid rate when the essential conditions are favorable.

More soluble salts permit greater concentration of the solutions, and stalactites of such salts often grow very rapidly. A copper sulfate stalactite 27 inches (67.5 centimeters) long and 1 inch (2.5 centimeters) in average diameter on the 1,400-foot level of the Briggs mine, at Bisbee, Arizona, was formed in 17 months.[5] On the assumption that the conditions were constant this represents a rate of 1.68 inches (3.95 centimeters) a month. Photographs showing the stalactites of chalcanthite and limonite hanging from mine timbers at Butte, Montana, have been widely reproduced.[6]

WILLIAM DRUMM JOHNSTON, JR.
U. S. GEOLOGICAL SURVEY

BLACK PAPER FOR CAMERA LUCIDA DRAWINGS

IN the use of the camera lucida some difficulty is frequently experienced in seeing clearly the object when white drawing paper is used.

Quite accidentally, the writer discovered that the object stands out much more definitely when a black surface is the drawing medium.

Black drawing paper (charcoal paper) may be secured in any store that carries a good line of drawing materials, and it is very satisfactory. Some difficulty was experienced in getting a pencil that was, in the first place, hard enough to take a good point, and, in the second place, of a color that would stand out well on a black background. An Eversharp carrying yellow lead was found best for the purpose. This lead can be sharpened to a needle point on fine sandpaper and is sufficiently hard to hold this point.

A controllable source of illumination on the drawing paper has been found beneficial in making the point of the pencil stand out more clearly. This is particularly true if the work is being done in a dark room or at night.

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[2] V. C. Allison, "The Growth of Stalagmites and Stalactites," *Jour. Geology*, 31: 106–125, 1923.

[3] J. S. Curtis, "Silver-lead Deposits of Eureka, Nevada," U. S. Geol. Survey Mono. 7, pp. 56–58, 1884.

[4] Oral communication.

[5] G. J. Mitchell, "Rate of Formation of Copper Sulfate Stalactites," *Am. Inst. Min. Eng. Trans.*, 66: 64, 1921.

[6] W. H. Weed, "Geology and Ore Deposits of the Butte District, Montana," U. S. Geol. Survey Prof. Paper 74, pl. 8, 1912.

SPECIAL ARTICLES

GEOGRAPHICAL INDEX NUMBERS

THE term geographical index number is a mathematical expression intended to represent the intensity of man's utilization of the environment or, as some would say, the quantitative determination of a geographical relationship. A hypothesis is established that a complete harmony between man and environment or a maximum geographical relationship has an index value of 100. Thus, in computing the geographical index numbers, the object is to determine and express in the form of a ratio what man is doing with what he should do in order to utilize most efficiently the environment. The word utilization is here defined to include the thought of control, adaptation or use of the environment.

Quite evidently, any attempt to measure quantitatively such variable components as man and environment is subject to conjecture. In fact, the supposition may seem unscientific because, in the opinion of some students, the nature of a geographical relationship or man's utilization of the environment will not lend itself to classification. The probable error of such quantitative determinations has been referred to as being so high that the results are scarcely more than personal judgments. These assertions may apply to the methodology or technique of measuring geographical relationships, but they do not exclude the possibilities of solving the problem within the limits of the probable error.

Apparently there has been very little attention directed towards quantitative analysis or synthesis of the reciprocal relationships between man and environment, if one can judge from known literature and discussions. The science has not advanced far beyond the descriptive stage—a situation, however, that does not reduce the significance of index numbers. In other social sciences, particularly economics, index numbers have a potent position. This should be equally true in geography. The effort to determine quantitatively the relationships between human activities and their settings represents time well spent, regardless of results. It fosters a greater interest in the classification, correlation, interpretation and application of geographical data, thus placing geography in the realm of a true science. The concentration of factors involved in a geographical relationship into one mathematical expression or figure necessitates careful weighing of the individual factors both human and environmental. The results are likely to be more representative and less misleading than when the same geographical relationship is expressed in a lengthy dissertation. Another salient feature of index numbers is their adaptability to maps. Geographical index numbers can be easily placed on maps, thus disclosing the nature of the environmental elements which in many cases can not be shown on one map. Through the addition of geographical index numbers physical maps may be converted into geographical maps.

The method of procedure in the determination of the geographical index number is as follows. In formula G. I. N. $= \frac{U^d \times 100}{U^m}$, G. I. N. represents the geographical index number; U^d represents present degree or intensity of utilization, and U^m represents maximum degree or intensity of utilization.

The values of U^d and U^m are expressed in terms of digits 1 to 10. Since the digit value of the maximum degree of utilization equals 100 per cent. the formula may be expressed in the form of a ratio as:

U^m (maximum utilization) : 100 = U^d (present utilization) : X (geographical index number).

The digit value of U^d and U^m are determined from the following expressions:

$$U^d = A^d \times P^d \text{ and } U^m = A^m \times P^m$$

(m) represents maximum
(d) " present degree
(P) " productivity
(A) " activity

Let us apply these equations to a given field in which the cultivation of corn is the major form of activity. A careful analysis of the human factors involved in the utilization of said field, such as method of cultivation, equipment, market conditions and transportation facilities, show that they have a digit value of 6. That is, each one of the human factors is graded on the basis of 1 to 10 as to degree of efficiency. Then the digit values of all human factors are added and the average determined. If the human side of the equation in the above illustration had been recognized as excellent then the digit value would have been recorded as 10. Thus the component (A^d), present activity, has a digit value of 6 in expression $U^d = A^d \times P^d$.

In the determination of (P^d), present productivity, such physical factors as soils, topography, climate and biological elements, and such locational factors as position, area and distance, are considered with reference to the growing of corn in the above illustration. The digit value of the physical factors is determined on a basis similar to that used in the determination of the human factors. The results show that the digit value of the physical factors is 8. Again, if the

conditions had been ideal for the production of corn the digit value would have been 10.

Since $U^d = A^d \times P^d$, $\therefore U^d = 6 \times 8 = 48$; that is, the present degree of utilization of said field has a digit value of 48.

The next step in the determination of the geographical index number is to consider the digit value of the maximum degree of utilization. It may be repeated for the purpose of clearness that the most efficient utilization of a given area is recognized as the maximum utilization or geographical relationship. Again, referring to the above illustration, let us suppose that (A) activity has a digit value of 10 if cotton is grown, while the digit value for corn as stated above is 6. Thus the (A^m) maximum activity has a digit value of 10. It is also assumed the component (P) has a digit value of 10 for cotton and only 8 for corn. Thus, the (P^m) maximum productivity has a digit value of 10.

Since $U^m = A^m \times P^m$, $\therefore U^m = 10 \times 10 = 100$. In other words, it is much more advisable so far as the geographical relationship is concerned to grow cotton than corn because the digit value for corn is 48 as compared to 100 for cotton.

In completing the formula, G. I. N. $= \frac{U^d \times 100}{U^m}$, or $= \frac{48 \times 100}{100} = 48$. Thus the geographical index number for the given field is 48. (It should be kept in mind that the digit value of the maximum utilization is always equal to 100 per cent and that a maximum geographical relationship is 100.)

The question undoubtedly comes to the reader as to how the digit values are determined. Are they largely personal estimates? However, after a careful consideration of maps, statistics, field work and consultation with specialists in the respective sciences the problem assumes a tone of encouragement. The satisfaction reaches the point where the results are above estimates, at least, more than personal opinions. As previously stated the attempt to place on a quantitative basis the factors involved is a worthy step towards the establishment of geography as a true science.

Another query about geographical index numbers pertains to the difficulty of determining what shall be recognized as the most efficient use of the land. Shall it be considered from the interests of an individual, a community, a state, a nation or society as the human race? With the tendency to consider geography as chorography, or a study of regions, it may be safe to say that the degree of utilization should be considered from the point of view of the occupants of the accepted region. There may be reasons at times to consider the problem from the interests of the individual or even nations. It all depends upon the objective.

In conclusion it may be said that geographical index numbers are intended to show the intensity of man's utilization of the environment or the geographical relationship. A low geographical index number suggests inefficient use of the environment. It may be the reader's interest to determine why a given region or area is not more effectively utilized. Areas of low geographical index numbers should disclose the future lands for human occupancy if the index numbers fulfil their purpose. Indeed, it is not assumed that it is always advisable for man to use his environs most efficiently. In other words, there are factors other than those classified as geographic that enter into the activities of man. Geography is not a science of determinism.

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OVERWINTERING OF THE FIRE BLIGHT PATHOGEN, BACILLUS AMYLOVORUS, WITHIN THE BEEHIVE[1]

IN a former article[2] the writer discussed the pioneer work of Merton B. Waite, who showed that the honey-bee is capable of acting as a carrier for the fire blight germ. Waite, as is well known, produced artificial epidemics of blossom blight by inoculating pear blossoms with pure cultures and then noting the relationship of bees in disseminating the pathogen from inoculated or diseased blooms to healthy ones.

Following Waite's work it has been commonly assumed that under natural conditions bees and other insects obtain the inoculum from drops of ooze or exudate that are extruded in the early spring from blight cankers located on diseased trees. In other words, while Waite had presented no evidence to show that under field conditions the insects obtain the inoculum from bacterial exudate originating in overwintered cankers, his findings of bacterial dissemination by bees from artificial infections has been used as a basis for the assumption that bees and other insects obtain the inoculum from oozing cankers. And, notwithstanding the fact that Waite[3] in his later articles makes no mention of bees as visitors or disseminators of primary inoculum from exuding cankers, though mentioning wasps and flies as acting in this capacity in one of his articles (a theory of Waite's for which no proof has been presented), it has been almost universally assumed up until recently

[1] Research paper No. 209, Journal series, University of Arkansas.

[2] SCIENCE, 70: 355, 1929.

[3] *Trans.* N. Y. State Agr. Soc., 1897: 779–790, 1898. Thirty-first Fruit Growers Conv. State Cal., 1905: 137–155, 1906. *Proc.* W. Va. State Hort. Soc., 1911: 66–73, 1912.

that bees and other insects, chiefly pollinating and nectar-seeking ones, obtain infectious material from "holdover" blight and spread it to the newly developed bloom. In accordance with this assumption the removal of blighted limbs from infected trees has been the main recommendation, often the only one, for controlling this disease.

Beginning with the observations of Stevens and his associates[4] in 1918 on the dissemination of the blight-producing pathogen by wind, there have been a number of investigators who have questioned the rôle of insects either in disseminating the blight producer after the disease started[5] or as agents of initial dissemination,[6] and some excellent evidence has been presented to show that rain falling over exuding cankers may readily act as a disseminating agent. But so far as the writer knows no concerted effort has been made by these investigators to explain the fact that, with relatively few exceptions, the first signs of blight in bearing orchards are to be found usually in the blossom clusters. Inasmuch as several investigators have presented rather conclusive evidence showing that young pear and apple leaves may readily be infected through natural openings by means of water suspensions of the pathogen, why then are the foliar shoots relatively free from disease in an orchard where they develop simultaneously with the bloom and where the latter may show a high percentage of infection?

It is this question plus one other consideration which has made it appear worth while to investigate the source of inoculum which may be involved in the first spring infections. The other consideration arose from the fact that no infectious exudate from overwintered cankers has been found to occur in the Ozarks of Arkansas prior to the first signs of blight, as reported in a previous publication.[7]

Aside from the overwintering of fire blight bacteria within twigs and limbs which were diseased the previous year, there are several other possible sources of overwintered inoculum. Among these are, first, bacterial masses freed as exudate during the previous growing season and remaining alive over winter, or bacteria freed by the disintegration of formerly diseased material, including leaves, succulent and woody shoots, flowers and fruits; second, the carrying over winter of the germ within the living quarters of insects which had previously come in contact with diseased material, or the adherence of the bacteria directly on the insect bodies. Indicative of the first possibility, evidence has been obtained which suggests that this may be true but which at this time is considered to be inconclusive. For the present it may suffice to note that certain strains of bacteria of proved pathogenicity have been isolated in the early spring from diseased material, strains which morphologically and physiologically are markedly different from the ordinary ones of *Bacillus amylovorus*.

Considering the second possibility, the writer has successfully isolated the fire blight pathogen from beehive material gathered throughout the summer, winter and early spring and from the bees themselves obtained from the hives in the early spring prior to the development of blight. The details of this work will be reported elsewhere. It may be stated that technique of isolation is extremely important in this instance. There remains to be determined, however, whether these findings are applicable to various sections of the country, and under diverse climatic conditions.

In the meantime it appears likely that we now have an explanation for the common occurrence of blossom blight in the absence of twig blight and in the absence of early spring oozing from blighted twigs and limbs. It is also probable that an explanation is at hand for the failures to control blight in orchards where painstaking, current remedial methods have been used, including the removal of blighted wood.

As a matter of caution it should be noted that even if the present findings will be duplicated in different parts of the country this does not mean that bees can be dispensed with. As long as self-sterile pears and apples are grown, these insects seem essential for proper pollination. The problem of control involves, among other things, the maintenance of uninfested beehives, and the failure to recognize this must at least in part account for the gradual extinction of the pear industry in America.

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[4] SCIENCE, 48: 449–450, 1918.

[5] *Ohio Agr. Exp. Sta. Bul.*, 357: 83–126, 1922; *Mich. Agr. Exp. Sta. Tech. Bul.*, 97, 32 pp., 1929.

[6] *Jour. Agr. Res.*, 39: 579–621, 1929.

[7] *Ark. Agr. Exp. Sta. Bul.*, 244, 96 pp., 1929.

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